MONTGOMERY WATSON

December 2, 1997

Dr. Mike McGuire
McGuire Environmental Consultants, Inc.
469 25th Street
Santa Monica, CA 90402-3103

Re: Revised Proposal for Perchlorate Treatability Study for the Main San Gabriel Basin Watermaster

Dear Mike,

Enclosed is our revised proposal for conducting an ion-exchange treatability study for the removal of Perchlorate from the San Gabriel Basin groundwater. The revisions made to were in accordance with our telephone conversation on November 25, 1997.

We hope that this revised proposal is to your satisfaction, and we look forward to working with you and the Watermaster staff on this important project. In the meantime, if you have any questions or comments about the proposal, please do not hesitate to contact me at (626) 568-6744.

Sincerely yours,

Issam Najm, Ph.D., P.E.
Manager,
Applied Research Department

enclosure

cc: Rhodes Trussell
Dennis Clifford
David Eberhold
Harold Glaser

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MAIN SAN GABRIEL BASIN WATERMASTER

BENCH- & PILOT-SCALE EVALUATION OF ION-EXCHANGE FOR PERCHLORATE REMOVAL FROM SAN GABRIEL GROUNDWATER

SCOPE OF WORK
December 5, 1997

INTRODUCTION

Perchlorate (ClO_4^-) has been detected in various California groundwaters, including the San Gabriel basin groundwater, at levels as high as 1,000 ug/L, and most recently in the Colorado River water at 7 to 9 ug/L. During a recent survey, perchlorate was detected in 69 out of 232 wells monitored in California. The sources of perchlorate contamination in various groundwaters has not been conclusively identified. However, contamination has been found in the vicinity of several former manufacturers and/or users of solid rocket fuel in northern and southern California.

Perchlorate has been used in medicine at very high doses for the treatment of Graves' disease and therefore, there is an abundance of health effects information on it. When ingested at these high levels, perchlorate inhibits the ability of the thyroid gland to perform its normal function.

As a result of reviewing the 1992 and 1995 evaluations of perchlorate by the USEPA, the California DHS' Drinking Water Program considers the 18-ppb concentration of perchlorate in drinking water to be protective of public health and has established this as its official action level. There is a possibility that the action level could be reduced in the future. If so 4 µg/L seems to be a likely minimum for two reasons: it is the MDL of the analytical method and it is the lower range of CalDHS' regulatory window, depending on the safety factor used.

Perchlorate is an extremely stable ion in water, and there is limited information on effective treatment technologies for its removal. However, several investigators are currently evaluating the use of anaerobic biodegradation for the removal of perchlorate from contaminated groundwater. Bench-scale testing conducted by Montgomery Watson has also shown that ion-exchange (IX) is a promising perchlorate treatment alternative, and has identified at least one resin with a sufficiently high capacity for perchlorate. However, there are no available information on long-term resin capacities for perchlorate, or published information on pilot-scale or full-scale applications and their performance.

This document includes a proposal for conducting bench-scale and pilot-scale evaluation of the ion-exchange process for the removal of perchlorate from San Gabriel basin groundwater.

GENERAL PROJECT APPROACH

A total of five tasks will be conducted. The first task involves the development of a thorough experimental plan for the bench-scale and pilot-scale testing programs. The plan will be submitted to the Watermaster for review and comments. The plan will then be revised based on the comments received.

During the second task, a project workshop will be convened in Pasadena, California. The objective of the workshop is to identify the resins to be tested during the bench-scale testing program (Task 3), and identify specific resin regeneration procedures. The workshop will be attended by the Montgomery Watson project team, the Watermaster project staff, and Dr. Dennis Clifford of the University of Houston. Dr. Clifford is a national expert on the application of IX processes in water treatment, and his input to the project will be very valuable.

The third task will include the bench-scale testing program. In this task, a bench-scale ion-exchange column setup will be constructed and used to screen various resins. A total of three (3) resins will be selected during the project workshop (Task 2). The bench-scale testing will focus on comparing the three resins, evaluating resin regeneration efficiency, and evaluating biodegradation as a brine treatment alternative.

The fourth task includes the pilot testing program. The first subtask of that program includes the mobilization and setup of Montgomery Watson's ion-exchange pilot unit. The unit will be installed at the Big Dalton well. The well-water has been reported to contain perchlorate ranging from 30 µg/L to as high as 100 µg/L. The pilot column will be run for a period of 8 weeks and sampled daily for influent and effluent perchlorate concentrations. Considering that the IX resin to be evaluated is not known at this time, it is not possible to estimate how many regeneration cycles will be achieved during the 8-week testing period. However, it is important that a minimum of four cycles be conducted in order to evaluate the long-term performance of the process.

The fifth task will include the development of a technical memorandum that includes the results of the bench-scale and pilot-scale testing results. The memorandum will also include an economic analysis of the cost of the IX process for perchlorate treatment of the San Gabriel Basin water.

As noted above, Professor Dennis Clifford of the University of Houston, TX, will serve as the technical advisor to the project. Dr. Clifford is a national expert on IX processes for water treatment. In this role, Dr. Clifford will provide review of the project experimental plan, pilot testing results, and technical memorandum. He will also travel to Pasadena to participate in the resin selection workshop.

SCOPE OF WORK

A total of five tasks will be conducted. These tasks are as follows:

Task 1: Prepare Experimental Plan
Task 2: Convene Project Workshop
Task 3: Conduct Bench-Scale Testing
Task 4: Conduct Pilot-Scale Testing
Task 5: Prepare Technical Memorandum

The following is a detailed description of the activities in each task.

Task 1: Prepare Experimental Plan

During the first four weeks of the project, Montgomery Watson will develop a detailed experimental plan for both the bench-scale and pilot-scale testing programs. The plan will include the following:

1. Description of the bench scale testing program,
2. Description of the pilot column testing setup,
3. Description of how each test will be conducted,
4. List of the number of samples to be collected from each column and their sampling locations,
5. Data logsheets to be used by the pilot scale operator.

The experimental plan will be submitted to the Watermaster for review and comments. After receiving the review comments, the experimental plan will be revised and submitted in its final format to the Watermaster.

Task 2: Convene Project Workshop

As noted above, a project workshop will be convened in Montgomery Watson's offices in Pasadena. The objective of the workshop is to identify the resins to be tested during the bench-scale testing program (Task 3), and identify specific resin regeneration procedures. The workshop will be attended by the Montgomery Watson project team, the Watermaster project staff, and Dr. Dennis Clifford of the University of Houston. Dr. Clifford is a national expert on the application of IX processes in water treatment, and his input to the project will be very valuable.

Task 3: Conduct Bench-Scale Testing

Prior to pilot-scale testing, Montgomery Watson will conduct bench-scale ion-exchange testing for the purpose of screening a total of three (3) ion-exchange resins. The bench testing program will address three primary issues:

1. Determine the long-term capacity of each of the three resins tested.
2. Evaluate the regeneration efficiency of each resin, and
3. Evaluate biodegradation as a brine treatment alternative.

The bench-scale testing will be conducted in Montgomery Watson's Research Laboratory in Monrovia, California. All testing will be conducted using groundwater samples obtained from the Big Dalton well. The sample will be spiked with 100 µg/L perchlorate so as to compress the bench-scale testing schedule. The bench testing setup will include three IX columns operated in parallel. The columns will be filled with the three ion-exchange resins selected for testing, and will be operated under the same loading rates as full-scale IX processes (i.e., approximately 2 gpm/ft^2). The spiked water will then be fed to each column, and samples will be collected from the effluent of each column to capture the breakthrough profile of each of the main cations present in the water. The analysis will focus on bicarbonate, nitrate, sulfate, and perchlorate. After each column reaches 70 percent breakthrough of perchlorate, it will be regenerated using a salt solution, and then put back on-line. The strength of the salt solution, and the regeneration strategy will be discussed during the project workshop. The brine from each regeneration cycle will be analyzed for all four cations to evaluate the regeneration efficiency. A maximum of five runs will be targeted for each resin. However, the ability to achieve this maximum number within the allotted time period of six (6) weeks will depend on the affinity of each resin for perchlorate.

Brine treatment is an important element in evaluating the practical and economic feasibility of IX for perchlorate removal from contaminated groundwater. The bench-scale testing will include an evaluation of biological degradation as a treatment alternative for the perchlorate-laden brine solution. This process has been validated for the removal of high levels of perchlorate from water. However, the high TDS of the brine solution may be problematic for this treatment process. Work conducted by Dr. Clifford at the University of Houston has shown that biodegradation can be used for the removal of nitrate from IX brine solutions.[1] As such, it is also expected to be successful for the removal of perchlorate from a similar high-TDS solution.

Biodegradation testing will be conducted in a batch mode as described by Liu and Clifford (1996). However, we understand that AEROJET will be conducting a biological treatment pilot study in northern California. In order to avoid the need for a lengthy biological acclimation period and to expedite the progress of the test, it will be necessary to acquire a biological seed from the AEROJECT biological treatment pilot plant. A portion of the brine solution will be dosed with a predetermined amount of methanol,[2] mixed with the biological seed in a closed container, and allowed to react over a period of 24 hours. The sludge will then be allowed to settled, and the decant water will be analyzed for perchlorate, nitrate, sulfate, and bicarbonate.

[1] Liu, X. & D.A. Clifford. "Ion Exchange With Denitrified Brine Reuse." *Journal AWWA*, 88:11 (1996)
[2] The methanol dose will be determined based on the concentration of nitrate and perchlorate in the brine solution

Task 4: Conduct Pilot-Scale Testing

As discussed above, an IX pilot unit will be set up at the Big Dalton well in the San Gabriel basin. The groundwater at the well already contains perchlorate at levels ranging from 30 µg/L to 100 µg/L. The column influent and effluent streams will be monitored for perchlorate, bicarbonate, chloride, nitrate, and sulfate concentrations. A hydraulic loading rate of 2 gpm/ft^3 of resin will be used during the pilot testing. At this rate, the 4-inch diameter pilot column will require a water flowrate of 660 mL/min (0.175 gpm).

A salt solution (NaCl) will be used to regenerate the resin at the end of each cycle (i.e., when perchlorate breaks through the column at levels exceeding the current 18 µg/L action level). The brine solution will then be analyzed for perchlorate, bicarbonate, chloride, nitrate, and sulfate concentrations in order to conduct a mass balance on each ion, and thus estimate the recovery of each ion during regeneration. Conducted over consecutive cycles, this analysis will help determine the long-term performance of the resin.

Due to the small scale of this test, we anticipate that the brine solution from the pilot testing will be discharged into the local sewer. However, before the start of this task, Montgomery Watson will coordinate with the Watermaster in obtaining the necessary approvals from the Los Angeles County Sanitation District for the discharge of the brine. Assuming that the process efficiency is approximately 95%, the volume of the brine solution is estimated at only 12 gallons per day.

Task 5: Prepare Technical Memorandum

After Task 4 is completed, a draft technical memorandum will be prepared. The memorandum will include details of the pilot-scale tests, and present and discuss the testing results. The technical memorandum will also include an economic analysis of the applicability of the ion-exchange process for the removal of perchlorate from San Gabriel groundwater. The analysis will include engineering estimates of the capital and O&M cost of the IX process.

The draft technical memorandum will be submitted to the Watermaster for review and comments. Once the review comments are received, Montgomery Watson will revise the draft memorandum and submit in final form to the Watermaster.

PROJECT SCHEDULE

The project will extend over a total of six months. The development of the experimental plan will be completed within two weeks from the date of receipt of the notice-to-proceed from the Watermaster. During the following six weeks, the project workshop will be convened, and the bench-scale testing program will be completed. The pilot-scale testing will then be conducted during the following 10 weeks. The results of the project tasks will then be analyzed and included in the draft technical memorandum to be submitted to

the Watermaster 22 weeks after the beginning of the project activities. The revised final technical memorandum will be submitted to the Watermaster two weeks after receipt of the Watermaster's comments on the draft memorandum.

PROJECT BUDGET

The overall project budget is estimated at $150,000. Table 1 includes a breakdown of the project budget by Task.

Table 1

Breakdown of Project Budget By Task

Task	Labor	ODCs	Total
1. Experimental Plan	$8,300	$1,700	10,000
2. Workshop	$2,000	$2,500	$4,500
3. Bench-Scale Testing	$35,300	$20,400	$55,700
4. Pilot-Scale Testing	$48,700	$12,900	$61,600
5. Technical Memorandum	$16,000	$2,200	$18,200
PROJECT TOTAL	$110,300	$39,700	$150,000